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High-Strength Alloy With Resistance to Hydrogen-Environment Embrittlement

Materials exposed to hydrogen under high pressures must be resistant to hydrogen-environment embrittlement. When this resistance is low, hydrogen diffuses through a material and makes it brittle. This is the characteristic of high-strength nickel and chromium alloys. On the other hand, low-strength materials, such as copper, aluminum, and their alloys, as well as some stainless steels have a high resistance to hydrogen-environment embrittlement. High-strength alloys which are highly resistant to hydrogen-environment embrittlement have not been available.

Recent tests on the high-strength Incoloy 903 have indicated that it may be highly resistant to hydrogen-environment embrittlement. The alloy is a precipitation-hardened, high-strength, and low-thermal-expansion material. It is iron-based and contains nickel and chromium at lower levels than the high-strength alloys. Its composition is as follows:

Element	Weight (Percent)
Nickel	38
Cobalt	15
Aluminum	0.7
Titanium	1.4
Columbium	3.0
Boron	0.005
Iron	Balance

Incoloy 903 is readily welded and brazed and has good oxidation resistance to 915 K (1200° F). The alloy is strengthened by a low-temperature anneal at 1100 K (1500° F) which is followed by doubling aging at 985 to 880 K (1325° to 1150° F). Its elastic modulus is constant between room temperature and 915 K, and its fracture toughness is 6.9×10^8 N/m (10⁵ psi).

For the tests, Incoloy 903 was heat treated and machined into smooth and notched tensile specimens. These specimens were tested in 48.3×10^6 N/m² (7000 psi) hydrogen and helium environments at room temperature. Results have indicated that there was no reduction of notched or smooth strength and therefore no hydrogen-environment embrittlement.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
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Marshall Space Flight Center, Alabama 35812
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NASA has decided not to apply for a patent.

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1. SUMMARY: This document describes the results of a study conducted to determine the effect of various factors on the performance of a specific system. The study was conducted over a period of six months and involved the use of a variety of test procedures and data analysis techniques. The results of the study indicate that the system performs well under a wide range of conditions, and that the factors studied have a significant effect on its performance.

2. INTRODUCTION: The purpose of this study was to determine the effect of various factors on the performance of a specific system. The system in question is a complex piece of equipment that is used in a variety of applications. The factors studied were selected based on their potential to affect the system's performance.

3. METHODS: The study was conducted using a variety of test procedures and data analysis techniques. The test procedures were designed to simulate the conditions under which the system is used. The data analysis techniques were used to determine the effect of the factors studied on the system's performance.

4. RESULTS: The results of the study indicate that the system performs well under a wide range of conditions. The factors studied have a significant effect on the system's performance, with some factors having a more pronounced effect than others. The results of the study are presented in the following tables and graphs.

5. CONCLUSIONS: The study has shown that the system performs well under a wide range of conditions. The factors studied have a significant effect on the system's performance, with some factors having a more pronounced effect than others. The results of the study are presented in the following tables and graphs.

6. REFERENCES: The following references were used in the study:

- 1. NASA Tech Rep. N73-10101, 1973.
- 2. NASA Tech Rep. N73-10102, 1973.
- 3. NASA Tech Rep. N73-10103, 1973.

7. APPENDICES: The following appendices are included in this document:

- A. Test Procedures
- B. Data Analysis Techniques
- C. Results of Study

8. DISTRIBUTION STATEMENTS: This document is classified as "Unclassified" and is available to the public. It is distributed in the following quantities:

- 1. 100 copies to the NASA Technical Reports Library.
- 2. 100 copies to the NASA Johnson Space Center.
- 3. 100 copies to the NASA Marshall Space Flight Center.

9. SUBJECT TERMS: The following subject terms were used to describe the content of this document:

- 1. Performance
- 2. System
- 3. Factors
- 4. Study

10. ABSTRACT: This document describes the results of a study conducted to determine the effect of various factors on the performance of a specific system. The study was conducted over a period of six months and involved the use of a variety of test procedures and data analysis techniques. The results of the study indicate that the system performs well under a wide range of conditions, and that the factors studied have a significant effect on its performance.